CLUTCH FOR ROTARY POWER TOOL AND ROTARY POWER TOOL INCORPORATNG SUCH CLUTCH

FIELD OF THE INVENTION

[0001] The present invention relates to a clutch for a rotary power tool, and relates particularly, but not exclusively, to an overload clutch for a handheld power hammer. The invention also relates to a handheld power hammer incorporating such a clutch.

BACKGROUND OF THE INVENTION

[0002] Rotary hammers are known which have a housing and a hollow cylindrical spindle mounted in the housing. The spindle allows insertion of the shank of a tool or bit, for example a drill bit or a chisel bit, into the front end thereof so that it is retained in the front end of the spindle with a degree of axial movement. The spindle may be a single cylindrical part or may be made of two or more cylindrical parts, which together form the hammer spindle. For example, a front part of the spindle may be formed as a separate tool holder body for retaining the tool or bit. Such hammers are generally provided with an impact mechanism which converts the rotational drive from an electric motor to a reciprocating drive causing a piston, which may be a hollow piston, to reciprocate within the spindle. The piston reciprocatingly drives a ram by means of a closed air cushion located between the piston and the ram. The impacts from the ram are then transmitted to the tool or bit of the hammer, optionally via a beatpiece.

[0003] Some hammers can be employed in combination impact and drilling mode or in a drilling only mode in which the spindle, or a forwardmost part of the spindle, and hence the bit inserted therein will be caused to rotate. In the combination impact and drilling mode the bit will be caused to rotate at the same time as the bit receives repeated impact. Such hammers generally also have a hammer only mode in which the spindle is locked against rotation.

[0004] Rotary hammers are known to have overload clutches in the drive train which transmits rotary drive from the motor to the spindle, or forwardmost part of the spindle. Such overload clutches are designed to transmit rotary drive when the transmitted drive torque is below a predetermined threshold and to slip when the transmitted drive torque exceeds the threshold. During rotary hammering or drilling, when working on materials of non-uniform hardness, for example aggregate or steel reinforced concrete, the bit can become stuck, which causes the torque transmitted via the rotary drive train to increase and causes the hammer

housing to tend to rotate against the grip of the user. An overload clutch can slip and interrupt rotary drive to the bit at a torque threshold below that where a user may experience difficulty in controlling the hammer. Accordingly, the clutch must slip reliably at a predetermined torque throughout the lifetime of the hammer, even after sustained use of the hammer.

[0005] An overload clutch of this type is disclosed in EP 0552328, in which a pair of cooperating ratchet plates are urged into engagement with each other by a compression spring. When a predetermined threshold torque is exceeded, for example as a result of the drill bit becoming stuck in a workpiece, the ratchet plates can slip relative to each other against the action of the spring. However, known overload clutches of this type suffer from the drawback that at very high torque levels, the ratchet plates can be moved rapidly out of engagement with each other to the extremities of their permitted relative movement and then move rapidly back into engagement with each other, causing problems in controlling the tool.

[0006] Preferred embodiments of the present invention seek to overcome the above disadvantages of the prior art.

BRIEF SUMMARY OF THE INVENTION

[0007] According to an aspect of the present invention, there is provided a clutch for a rotary power tool having a housing, a spindle rotatably mounted within the housing, and a motor for causing rotation of said spindle about a first axis, the clutch comprising:-

a first clutch member adapted to be mounted to said spindle and to rotate therewith and slide relative thereto in a direction substantially parallel to said first axis, said first clutch member having at least one first friction surface inclined in use relative to said first axis for engaging a respective corresponding second friction surface on said spindle as a result of movement of said first clutch member relative to the spindle;

first biasing means adapted to act between said spindle and said first clutch member for biasing said first clutch member towards a stop;

a second clutch member having a first condition in which said second clutch member engages said first clutch member and rotates therewith, and a second condition in which said second clutch member can move relative to said first clutch member; and

second biasing means adapted to act between said first and second clutch members for urging said second clutch member towards said first condition.By providing a first clutch member having at least one first friction surface inclined relative to the first axis for

engaging a respective corresponding second friction surface on the spindle, this provides the advantage of providing a reaction force, from the or each corresponding second friction surface on the spindle, which has a component resisting axial movement of the first clutch member relative to the spindle. This in turn reduces the tendency of the first clutch member to move axially too rapidly relative to the spindle.

[0008] In a preferred embodiment, said second clutch member is adapted to be mounted to said first clutch member and to slide relative thereto in a direction substantially parallel to said first axis, said first and second clutch members have cooperating engaging portions, and said second biasing means is adapted to urge said cooperating engaging portions into engagement with each other, such that when a torque applied between said first and second clutch members does not exceed a predetermined value, said cooperating engaging portions engage each other to prevent relative rotation between said first and second clutch members, and when said torque exceeds said predetermined value, axial movement of said second clutch member relative to said first clutch member against the action of said second biasing means occurs to disengage said cooperating engaging portions from each other, thereby permitting relative rotation between said first and second clutch members.

[0009] The first clutch member may be adapted to abut the second clutch member, and the cooperating engaging portions may comprise a plurality of teeth on said first and second clutch members.

[0010] The teeth may be adapted to engage each other by means of cooperating inclined surfaces.

[0011] The cooperating engaging portions may comprise at least one respective third friction surface on said first clutch member and at least one fourth friction surface on said second clutch member.

[0012] The first clutch member may be a drive gear adapted to be driven by means of the motor.

[0013] The first and/or second biasing means may comprise at least one respective compression spring.

[0014] The clutch may further comprise at least one resilient stop member adapted to engage said first clutch member at said stop.

[0015] This provides the advantage of minimising impact between the first clutch member and the stop.

[0016] Said first clutch member may further comprise a recess having an inclined surface for engaging at least one said resilient stop member.

[0017] This provides the advantage of bringing the first clutch member into more controlled engagement with the stop member.

[0018] The first clutch member may have a pair of said first friction surfaces, each said first friction surface inclined in use relative to said first axis for engaging a respective corresponding second friction surface on the spindle.

[0019] This provides the advantage of providing more effective braking of the first clutch member relative to the spindle for each direction of rotation of the spindle.

[0020] According to another aspect of the present invention, there is provided a clutch for a rotary power tool having a housing, a spindle rotatably mounted within the housing, and a motor for causing rotation of the spindle about a first axis, the clutch comprising:-

a first clutch member adapted to be mounted to the spindle and to rotate therewith and slide relative thereto in a direction substantially parallel to said first axis;

first biasing means adapted to act between said spindle and said first clutch member for biasing said first clutch member towards a stop;

a second clutch member having a first condition in which said second clutch member engages said first clutch member and rotates therewith, and a second condition in which said second clutch member can move relative to said first clutch member;

second biasing means adapted to act between said first and second clutch members for urging said second clutch member towards said first condition; and

at least one resilient stop member adapted to engage said first clutch member at said stop.

[0021] By providing at least one resilient stop member adapted to engage the first clutch member at the stop, this provides the advantage of minimising impact between the first clutch member and the stop, which in turn minimises the extent to which the first clutch member is brought back into engagement with the stop on the spindle too violently.

[0022] In a preferred embodiment, said second clutch member is adapted to be mounted to said first clutch member and to slide relative thereto in a direction substantially parallel to said first axis, said first and second clutch members have cooperating engaging portions, and said second biasing means is adapted to urge said cooperating engaging portions into engagement with each other, such that when a torque applied between said first and second clutch members does not exceed a predetermined value, said cooperating engaging portions engage each other to prevent relative rotation between said first and second clutch members, and when said torque exceeds said predetermined value, axial movement of said second clutch member relative to said first clutch member against the action of said second biasing means occurs to disengage said cooperating engaging portions from each other, thereby permitting relative rotation between said first and second clutch members.

[0023] Preferably, the first clutch member is adapted to abut the second clutch member, and the cooperating engaging portions comprise a plurality of teeth on said first and second clutch members.

[0024] The teeth may be adapted to engage each other by means of cooperating inclined surfaces.

[0025] The cooperating engaging portions may comprise at least one first friction surface on said first clutch member and a respective second friction surface on said second clutch member.

[0026] Said first clutch member may further comprise a recess having an inclined surface for engaging at least one said resilient stop member.

[0027] This provides the advantage of bringing the first clutch member into more controlled engagement with the stop member.

[0028] Said first clutch member may further comprise at least one third friction surface inclined in use relative to said first axis for engaging a respective corresponding fourth friction surface on said spindle.

[0029] By providing a first clutch member having at least one third friction surface inclined relative to the first axis for engaging a respective corresponding fourth friction surface on the spindle, this provides the advantage of providing a reaction force, from the or each corresponding fourth friction surface on the spindle, which has a component resisting axial movement of the first clutch member relative to the spindle. This in turn reduces the tendency of the first clutch member to move axially too rapidly relative to the spindle.

[0030] The first clutch member may have a pair of said third friction surfaces, each said third friction surface inclined in use relative to said first axis for engaging a respective corresponding fourth friction surface on the spindle.

[0031] This provides the advantage of providing more effective braking of the first clutch member relative to the spindle for each direction of rotation of the spindle.

[0032] The first clutch member may be a drive gear adapted to be driven by means of the motor.

[0033] The first and/or second biasing means may comprise at least one respective compression spring.

[0034] According to a further aspect of the present invention, there is provided a rotary power tool comprising:-

a housing;

a spindle rotatably mounted within the housing;

a motor for causing rotation of said spindle about an axis; and

a clutch as defined above mounted to said spindle.

[0035] Said cooperating engaging portions may comprise a tapered projection on one of said first and second clutch member and a tapered groove on the other of said first and second clutch members.

[0036] The tool may be a hammer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] A preferred embodiment of the invention will now be described, by way of example only, and not in any limitative sense, with reference to the accompanying drawings, in which:-

Figure 1 is a partially cut-away side cross-sectional elevation view of a rotary hammer embodying the present invention;

Figure 2 is a partially cut away perspective view of a spindle and overload clutch mechanism of the hammer of Figure 1;

Figure 3 is a rear end view of the mechanism of Figure 2;

Figure 4 is a sectional view along the line A-A in Figure 3;

Figure 5 is a sectional view along the line B-B in Figure 3;

Figure 6 is a sectional view along the line C-C in Figure 3;

Figure 7 is a sectional view along the line D-D in Figure 4;

Figure 8 is a perspective view of the spindle shown in Figure 2 with the overload clutch mechanism removed; and

Figure 9 is a cross-sectional elevation view of the rotary hub shown in Figure 2.

DETAILED DESCRIPTION OF THE INVENTION

[0038] Referring to Figure 1, a rotary hammer has a forward portion shown in cross-section, and a rear portion incorporating a motor and pistol grip rear handle in a conventional manner. Alternatively, the handle may be of the D handle type. The handle portion incorporates a trigger switch 7 for actuating an electric motor which carries a pinion (not shown) at the forward end of its armature shaft. The pinion of the motor rotatingly drives an intermediate shaft 6 via a gear which is press fit onto the rearward end of the intermediate shaft 6. The intermediate shaft 6 is rotatably mounted in a housing 2 of the hammer via a first bearing (not shown) located at the rearward end of the intermediate shaft 6 and a forward bearing 3 located at the forward end of the intermediate shaft 6.

[0039] A wobble drive hammering mechanism, of a type which will be familiar to persons skilled in the art, is provided for reciprocatingly driving a piston 24. The piston 24 is slidably located within a hollow cylindrical spindle 4 and an O-ring seal (not shown) is mounted around the piston 24 so as to seal between the periphery of the piston 24 and the internal surface of the spindle 4. A ram 28 is slidably mounted within the spindle 4 and an O-ring seal (not shown) is mounted around the ram 28 so as to seal between the periphery of the ram 28 and the internal surface of the spindle 4. In this way, during normal operation of the hammer, a closed air cushion is formed between the forward face of the piston 24 and the rear face of the ram 28, which causes the ram to be reciprocatingly driven by the piston via the closed air cushion. During normal operation of the hammer, the ram 28 repeatedly impacts a beatpiece 32, which is reciprocatingly mounted within the spindle 4. The beatpiece 32 transfers impacts from the ram 28 to a tool or bit (not shown) mounted within a forward tool holder portion of the spindle 4 by means of a tool holder arrangement 36, of a type which will be familiar to persons skilled in the art. The tool or bit is releasably locked within the tool holder portion of the spindle 4 so as to be able to reciprocate within the tool holder portion of the spindle by a limited amount.

[0040] The spindle 4 is rotatably mounted in the hammer housing 2 by means of bearings 5, 7. Simultaneously with, or as an alternative to, the hammering action generated by the hammering mechanism described above, the spindle 4 can be rotatingly driven by the intermediate shaft 6 as described below. Thus, as well as reciprocating, the tool or bit is rotatingly driven because it is non-rotatably mounted within the spindle 4 by the tool holder arrangement 36.

[0041] An overload clutch mechanism includes a spindle drive gear 40 rotatably and axially slidably mounted on a slider sleeve 41, and the slider sleeve 41 is non-rotatably and axially slidably mounted on the spindle 4. The spindle drive gear 40 is formed on its periphery with a set of teeth 43. The intermediate shaft 6 is formed at its forward end with a pinion 38 and the teeth 43 of the spindle drive gear 40 may be brought into engagement with the pinion 38 in order to transmit rotary drive to the slider sleeve 41 and thereby to the spindle 4. The spindle drive gear 40 transmits rotary drive to the slider sleeve 41 via the overload clutch arrangement. The spindle drive gear 40 has a set of rearwardly facing teeth 40a formed on a rearward facing surface thereof, this set of teeth 40a being biased into engagement with a set of teeth formed on a forward facing surface 41a on an annular flange of the slider sleeve 41. The sets of teeth are biased into engagement with each other by a spring 47 mounted on the slider sleeve 41 to

extend between a washer 49 axially fixedly mounted at the forward end of the slider sleeve 41, and a forward facing end surface of the spindle drive gear 40.

[0042] The slider sleeve 41 is axially biased by means of a spring 56 into a rearward position against an elastomeric O-ring 42 mounted in a recess 102 (Figures 4 and 5) formed in the external surface of the spindle 4 and having an inclined surface. In the rearward position, the hammer is in a rotary mode and rotation of the intermediate shaft 6 is transmitted to the spindle 4, provided the torque transmitted is below a threshold torque of the overload clutch, the operation of which will be described in greater detail below.

[0043] The slider sleeve 41 can also be moved into a forward position against the biasing force of the spring 56 via a mode change mechanism. In the forward position, the spindle drive gear 40 is moved on the slider sleeve 41 forwardly out of engagement with the intermediate shaft pinion 38 and into engagement with a spindle lock arrangement 60, the function of which is not relevant to the present invention and will therefore not be described in further detail. With the slider sleeve 41 and spindle drive gear 40 in a forward position, the hammer is in a non-rotary mode with the spindle 4 fixed against rotation. The mode change arrangement may comprise a mode change knob 55 rotatably mounted on the housing 2 and having an eccentric pin 57 which is engageable with the rearward face of the annular flange 41a of the slider sleeve 41 to move the slider sleeve forwardly.

[0044] In the position shown in Figure 1, the spring 56 biases the slider sleeve 41 into its rearward position. However, on rotation of the mode change knob through 180 degrees from its position shown in Figure 1, the eccentric pin 57 pulls the slider sleeve 41 forwardly against the biasing force of the spring 56. The eccentric pin 57 then pulls the slider sleeve 41 forwardly to move the spindle drive gear 40 out of engagement with the pinion 38 of the intermediate shaft 6 and into engagement with the spindle lock arrangement 60.

[0045] Referring now to Figures 2 and 8, the external surface of the spindle 4 is formed with a series of tapering grooves 104 which become narrower in a direction moving towards the forward end of the spindle 4. The slider sleeve 41 is provided with splines 106 which also taper in a direction towards the forward end of the slider sleeve 41. In this way, the slider sleeve 41 is prevented from rotating relative to the spindle 4, but can slide axially to a limited extent relative thereto. Referring to Figures 4 and 5, the rearward end of the slider sleeve 41 is provided with a recess 108 having an inclined internal surface for accommodating elastomeric O-ring 42.

[0046] The operation of the rotary hammer will now be described.

[0047] When the torque required to rotationally drive the spindle 4 is below a predetermined threshold, the spring 56 biases the slider sleeve 41 into engagement with elastomeric O-ring 42, and the spring 47 biases the sets of cooperating teeth on the spindle drive gear 40 and slider sleeve 41 into engagement with each other. With these sets of cooperating teeth engaged, rotation of the intermediate shaft 6 rotationally drives the spindle drive gear 40 via pinion 38, and the spindle drive gear 40 rotationally drives the slider sleeve 41 via the interlocking facing teeth. As a result, the slider sleeve 41 rotationally drives the spindle 4 by means of cooperation between the splines 106 on the slider sleeve 41 and the grooves 104 on the spindle 4.

[0048] When the torque required to rotationally drive the spindle 4 exceeds the predetermined torque threshold, however, the inclined surfaces of the mutually engaging teeth on the spindle drive gear 40 and slider sleeve 41 slide over each other, as a result of which the drive gear 40 slides forwardly along the slider sleeve 41 against the action of spring 47. This may occur, for example, as a consequence of the hammer bit becoming stuck in a hard workpiece such as concrete. As a result, the spindle drive gear 40 can rotate relative to the slider sleeve 41 and the cooperating sets of teeth ratchet over each other, preventing the rotary drive from the spindle drive gear 40 being transmitted to the spindle 4. Furthermore, the ratcheting of the sets of teeth makes a noise which alerts the user of the hammer to the fact that the overload clutch arrangement is slipping.

[0049] In the event of a very rapid increase in the torque applied to the clutch, for example as a result of the hammer bit (not shown) becoming stuck in a workpiece such as concrete, the slider sleeve 41 may also be moved forward rapidly against the action of spring 56, and one of the side surfaces of each spline 106 comes into contact with the facing surface of the groove 104 in the spindle 4. As a result, the splines and grooves abut each other at a sliding surface angled relative to the axis of rotation of the spindle 4, which abutment between the splines 106 and grooves 104 produces a reaction force having a component parallel to the axis of rotation of the spindle 4, tending to slow down movement of the slider sleeve 41 relative to the spindle 4. It has been found that this significantly reduces problems caused by rapid forward movement of the slider sleeve 41 relative to the sleeve.

[0050] As the slider sleeve 41 is urged backwards towards O-ring 42 under the action of spring 56, as the inclined surface of recess 108 in the rear face of slider sleeve 41 comes into contact with the O-ring 42, and the slider sleeve 41 returns to its rest position more uniformly and with less impact than in the case of a solid ring such as a circlip replacing the O-ring 42.

[0051] It will be appreciated by persons skilled in the art that the above embodiment has been described by way of example only and not in any limitative sense, and that various alterations and modifications are possible without departure from the scope of the invention as defined by the appended claims. For example, although the embodiment described in detail above is a torque overload clutch, it will be appreciated by persons skilled in the art that clutches of a different type may also be within the scope of the present invention.